IOWA STATE UNIVERSITY
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Volume 42 | Issue 2 Article 4

1980

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Brucellosis has been recognized as a highly contagious disease of man and animals since Bruce discovered the cause of Malta fever (*Br. melitensis*) in 1887.[5] *Br. abortus* was found to cause abortion in cattle twenty years later by Bang. Another species, *Br. suis*, was isolated from aborted swine fetuses by Traum in 1914. Brucellosis is now known to have a worldwide distribution, occurring in a variety of domestic species, such as sheep, goats, horses, and dogs, as well as several wild animals.[24] Because of public health implications and a potential threat to various livestock industries, the study of the epizootiology of brucellosis which is under way should be developed even further.

The causitive agents of the disease brucellosis are strains or species of the genus *Brucella*. In wildlife, those of importance include *Br. abortus*, *Br. suis*, *Br. canis*, and *Br. neotomae*. The accurate diagnosis of brucellosis is the key to the successful elimination of the disease. With this aim, researchers in the literature have utilized serological testing. In animals, however, the false positive as well as negative reactions occasionally obtained have made these results questionable.[1] Recent progress in the area has been helped by a better understanding of the nature of immunoglobins in man and other animal species, and their role in the reactions involved in different tests. As a result, techniques have been improved and results may be better interpreted.[1]

Brucellosis in wildlife in the U.S. was first diagnosed in 1917 in free-ranging bison in Yellowstone National Park.[20] Since then, the disease has been found to occur in several other species of wild ruminants, in wild carnivores, lagomorphs, rodents, and even arthropods such as fleas. (See table). Rarely has brucellosis been diagnosed in avian species, although they have been experimentally infected with *Brucella* spp. It is not believed that birds serve either as reservoirs or disseminators.[24]

TABLE 1. Isolation of *Brucella* spp. from Wild Hosts

Host Species	Reference
Alaskan sled dog	14
Alaskan wolf (*Canis lupus*)	5
Argentine fox (*Dusicon* sp.)	19
bison (*Bison bison*)	21
black-backed jackal (*Canis mesomelas*)	18
black-tailed jack rabbit (*Lepus* sp.)	21
bobcat (*Lynx rufus*)	7,8
camel (*Camelus* sp.)	22
Canadian goose (*Branta* sp.)	7
caribou (*Rangifer tarandus articus*)	11
cottontail (*Sylvilagus* sp.)	21
coyote (*Canis latrans*)	5
Dall sheep (*Ovis dalle*)	14
deer mouse (*Peromyscus* sp.)	21
desert wood rat (*Neotoma lepida*)	21
elk (*Cervus canadensis*)	20
feral swine (*Sus scrofa*)	3,25
flea (*Orehopeus*)	21
fox (*Vulpes vulpes*)	13
grizzly bear (*Ursus horribilis*)	5
hare (*Lepus europaeus*)	23
harvest mouse (*Reithrodontomys* sp.)	23
Maral deer	9
moose (*Alces alces*)	4
mule deer (*Odocoileus* sp.)	23
opossum (*Didelphis virginiana*)	16
Ord kangaroo rat (*Dipodomys ordii*)	23
pocket mouse (*Perognathus* sp.)	23
raccoon (*Procyon lotor*)	7,16
red fox (*Vulpes fulva*)	7
reindeer (*Rangifer tarandus*)	17
skunk (*Mephitis mephitis*)	8
spotted hyena (*Crocuta crocuta*)	18
squirrel (*Citellus* sp.)	23
western porcupine (*Erethizon* sp.)	23
white-tailed deer (*Odocoileus* sp.)	2
wild dog (*Lycaon pictus*)	18

Manifestations of brucellosis vary according to the nature and extent of the disease as well as the species involved.[24] Among the domesticated animals, dogs may not show signs and yet shed the organism. On

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the other hand, *Br. canis,* the specific etiologic agent, may cause reproductive failure, generalized loss of vigor, and a prolonged bacteremia.[7] In ruminants, brucellosis commonly induces abortions during the latter half of gestation and is more prevalent in cows calving for their first time. Calves are born immature, weak, and the placenta is frequently retained. Horses, although infrequently infected, have been known to develop abcesses from *Br. abortus* or *Br. suis,* localizing in the supraspinous bursa of the withers.[15,24] Brucellosis in swine localizes in the genital organs and joints.

Many of the same clinical signs seen in domestics have been reported in the literature to occur in wildlife. For example, abortions in bison were observed in Canada due to *Br. abortus.* In the bulls, scrotal enlargement and orchitis were the primary signs.[20] Also, in a study of elk artifically injected with this same species, 48% of 29 cows lost their first calf. Other signs of brucellosis were synovitis in the lower legs and secondarily-infected hygromata.[20] Moose appear to be affected somewhat differently than bison and elk. The disease produces generalized, apparently fatal, infection involving the body cavities, viscera (kidney, liver, and spleen), and scrotum or testes in the male.[20]

Research on brucellosis in white-tail deer in various parts of the United States has evidenced a low incidence of reactors in this species.[20,24] Authors on this subject have decided that although study results are inconclusive, they would raise some question regarding the effects of brucellosis on reproduction in the species.[20] Camels, too, have been known to become infected with brucellosis, causing abortion in pregnant animals. There have been herd infections reported from Asia as well as N. Africa.[22,24] *Brucella suis* infections in caribou and reindeer are similarly known to cause reproductive failure. The disease is characterized by orchitis-epididymitis, bursitis-synovitis, and metritis with abortion and retained placental membranes.[20] Whether abortion occurs in reindeer infected experimentally depends on the stage of pregnancy at time of inoculation as well as dosage given.[17]

Hares in Europe reportedly have been afflicted with brucellosis since the late 1800's. Wetzel and Rieck (1962) refer to "hare syphilis" and "tuberculosis of the scrotum" as being reported, which was later related to brucellosis. More recently, *Br. abortus* and *Br. suis* have been isolated from hares in various parts of Europe and Asia as well as in Utah.[21,24] Clinical signs of the disease are swollen testes, abortion, infected reproductive organs, and lesions in the viscera.[24]

Transmission of *Brucella* infections occurs most commonly through oral exposure.[24] Susceptible animals can also be infected by contamination of the genital tract, the eyes, or wounds. Males may transmit brucellosis by breeding after genital contamination by an infected female or via their own infected semen. It is reported that male reindeer play an important role in spreading the disease in the latter manner.[17] In the infected female animal, aborted fetuses, placentas, vaginal discharges, and milk from a *Brucella*-infected udder are all likely disseminating agents.[17,24] Davis (1979) noted the excretion of viable *Br. abortus* in post-partum vaginal discharges of coyotes for as long as 11 days and congential transmission as well. Another author, however, believes that because most pathogenic bacteria which cause placental lesions usually affect survival of the fetus, prenatal vertical transmission is not an efficient means of maintaining these infections in nature.[9] *Brucella* organisms have been known to be shed in urine and feces in domestic canines; therefore, the area potential for dispersion in far-ranging wild canids (i.e. coyotes) is great.[5]

It follows from these observations that carnivores are more readily infected than herbivorous animals in enzootic brucellosis areas, probably through ingestion of aborted fetuses and membranes.[5] In a study of *Br.* agglutinins in sheep and 38 wild animal spp. in California, six of the seven wild species found to have titers were carnivorous.[8] Another consideration to be made is the possible transmission of brucellosis from infected livestock to these animals. Davis *et al.* (1979) noted a high prevalence of *Br. abortus* in cattle in the area from which infected coyotes were detected in their study. Neiland *et al.* (1975) suggests that *Brucella* infections may interfere with reproduction of species of wildlife.[16]

Transmission of brucellosis during bacteremic stages of infection may occur utilizing blood-sucking parasites as vectors.[24]

Thorpe *et al.* (1965) isolated *Br. neotomae* from a flea, the species of which was known to parasitize desert wood rats. These rats were commonly infected with *Brucella neotomae*, also.

Brucellosis studies in a number of specific geographical areas have substantiated the claim that the disease may be enzootic in animal populations. If true, this could develop into a matter of public health importance in cases where it may be proven that wild animals can transmit the clinical disease to livestock and/or humans. In one 10 year survey of wildlife in central Utah, *Brucella* spp. were isolated from desert wood rats, jack rabbits, and a flea, and serological tests indicated that eleven other animal species as well had significant titers against the organism. Numerous cattle and sheep from the region and adjacent areas were also found to have high titers indicative of infection.[21] In addition to this, the wood rats infected with brucellosis were from different areas separated by as many as sixty-five miles and from desert terrain considered impassable for a small rodent. All of the wild animals which tested susceptible to *Br. neotomae*, the species specific for wood rats, were also susceptible to *Br. abortus*, *Br. suis*, and *Br. melitensis* (the latter naturally occurs in sheep and goats). The infective dose ranges were generally comparable to those of *Br. neotomae* as well.

Wildlife studies in the states of Texas and California have also made some observations about the distribution of brucellosis there and are support for the contention that there are wildlife reservoirs for the disease. Workers in eastern Texas found that *Br. abortus* is commonly disseminated in certain coyote populations in that region. Serologically positive coyotes from other areas of the state as well suggest that this is not simply a localized phenomenon.[7,8,16] Randhawa *et al.* (1977) found a good correlation between seropositive test results in cattle herds and in coyotes within the same county in Texas. In the state of California, which achieved certification as Brucellosis free in 1969, there has since been a reversal in the once steady downward trend of the disease in cattle. Both in Texas and in California[8], it is likely that carnivores (wildlife) pick up the infection from infected livestock and serve as a reservoir for it.

Negative evidence for transmission of brucellosis from wild animals to cattle is cited by other sources.[6,10] Friend (1978) reports there has not been a single instance of transmission of the disease from Yellowstone National Park bison to cattle in the surrounding area documented. Counties from the states adjoining the park have been brucellosis free for over 10 years.[6] Similar conclusions were drawn with regards to the intertransmissability of brucellosis between moose and cattle in Canada.[10] In a serological survey of 60 cow moose in an area of high prevalence for brucellosis, no reactors were found.

In other parts of the world, there is equal cause for concern with regards to potential economic losses due to brucellosis. Camels in Kenya number over a half million and are used for transport, milk, and meat by the African people. A 14% reactor rate to *Brucella* sp. in the NE province discovered in these animals by Waghela *et al.* (1978), therefore, could be of significant interest. The possibility exists that in wild deer farming programs to be developed in the future in Australia, New Zealand, Scotland, and elsewhere, the deer may be at risk from infected cattle also. For example, in Russia, *Br. abortus* biotype 6 is already a problem in that it causes brucellosis in the farmed Maral deer.[9] Reindeer, too, have their own variety of *Brucella suis* (biotype 4), thus creating its own problems in areas of the Soviet Union where the animals are of economic importance.[17]

Human infections caused by *Brucella* organisms have not been slighted in importance by this reviewer or by studies done in the literature. Man has been known to contract brucellosis from the milk of infected udders of cattle and reindeer as well as by ingesting contaminated meat.[24] Caribou hunters may acquire the disease through direct contact with the infected animals or through close relationships with their dogs, which have been known to shed the organism in their feces and urine.[20]

In a study comparing agglutinin levels for brucellosis in caribou with those of humans living in a wide geographical area, the higher titers were greatest among people living where the major herds range and large amounts of caribou meat was eaten. Cultures made from both sources produced the same strain (biotype 4) of *Br. suis.*[11]

What is currently known about the transmission of brucellosis in coyotes in Texas supports the view that *Br. abortus* in coyotes may also be of public health importance. There is a high risk of exposure in trappers, fur buyers, researchers, and veterinarians who handle coyotes.[5]

The high prevalence of brucellosis in feral swine in one county in Florida has important epidemiologic and zoonotic implications. Thirty-nine percent of the human brucellosis cases in that state were caused by swine in the twelve-year period 1963-1975.[3] In the Southeastern U.S., domestic swine are often reared outside where the opportunity exists for mingling with the wild species. This, as well as the fact that several hundred of the feral swine are translocated yearly throughout Florida, might allow for an increased dissemination of the disease.

In conclusion, it may be seen that brucellosis is of significant occurrence in the many wild animal species herein described. The next step to be taken in a national eradication program for the disease in man and animals is not an obvious one, due to the difficulties of identifying and eliminating brucellosis in wildlife. However, in that over 950 million dollars have already been spent for controlling this disease since 1934,[6] we should maximize the value of the monies already invested and minimize that spent in the future by clarifying the present situation. This will mean continuing the development of our knowledge of the disease in wildlife, their role in transmission, pathological effects on populations, and the persistence of the organism in wild animals.

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